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Waste Lubricating Oil Disposal Practices in Providence, Rhode Island: Potential Significance to Coastal Water Quality

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Abstract A 1979–80 survey of Providence, R.I., residents indicated that approximately 35 percent changed their own automotive lubricating oil, disposing of this oil by a variety of methods. The most popular method of disposal reported by the respondents was putting the oil in the garbage can (41 percent), followed by dumping it in their backyard (30 percent), pouring it down sewers or storm drains (8 percent), giving it to a service station (7 percent), pouring it on the road (5 percent), and taking it to a town dump (3 percent). The practice of pouring the waste oil on the road or into sewers on a weight basis can account for 44 metric tons of petroleum hydrocarbons discharged into the city's combined storm and sanitary sewage treatment system. This amount could account for approximately 19 percent of the total hydrocarbons discharged annually by this plant. Providence residents indicated a high degree of willingness to participate in a recycling program under consideration by the State Legislature of Rhode Island.

Introduction

Public concern about petroleum pollution of the marine environment has been heightened by the recent wide publicity given to oil spills. Dramatic events such as the *Argo Merchant, Amoco Cadiz,* and Ixtoc oil spills, however, overshadow some of the low-level, chronic discharges of petroleum into estuarine and coastal waters which, on a mass balance, contribute more oil to near-shore environments than these widely publicized oil spills. The U.S. Coast Guard (1976) estimated that tanker accidents contribute 25,000 metric tons of oil/year to U.S. coastal waters. Yet recent evidence indicates that inputs from coastal sewage treatment facilities may contribute nearly 50,000 metric tons of oil/year into U.S. coastal waters (Van Vleet and Quinn, 1978). Several studies have suggested that waste lubricating oil disposed of in sewers may account for a significant but unspecified proportion of this amount (Van Vleet and Quinn, 1978; Tanacredi, 1977). It has also been shown that chronically exposed shellfish accumulate the oil (Tanacredi, 1977; Farrington and Quinn, 1973) and do not depurate these petroleum hydrocarbons as readily as shellfish exposed to acute oil doses (Boehm and Quinn, 1977).

This study was initiated to determine how waste lubricating oil disposal practices could influence the quality of Rhode Island's estuarine and coastal waters. Estimates of the petroleum inputs to upper Narragansett Bay from sewage treatment plants on the Providence River are already available (Van Vleet and Quinn, 1977, 1978). The primary goal of this study was to determine what fraction of these petroleum hydrocarbons that come from sewage treatment effluents originate as the result of people dumping their waste lubricating oil in sewers or on the roads in Providence.

Methods

To obtain information on the relative magnitude of the different waste lubricating oil disposal methods used in the city, a structured questionnaire accompanied with a covering letter* was mailed to 1,000 Providence, Rhode Island, residents. The instrument was pretested twice, once by personal interviews and once by mailing, to determine the

*It was recognized that if the people surveyed thought that the questionnaire were environmentally oriented, they might be more inclined to answer with what they perceived to be the environmentally correct disposal method than to be honest and answer with what they actually did with their waste oil. Therefore, the covering letter camouflaged our environmental interest by stating that we were

questionnaire's readability and to estimate the return rate, respectively. The questionnaire asked respondents about the number of cars owned by their families, how frequently they changed the oil in their cars, whether they changed the oil themselves or took it to a gas station, how they disposed of the waste oil, whether or not they would bring this oil to a recycling center and where they thought the recycling barrels should be located. A copy of the questionnaire is given in Figure 1. The names of

Your answers will be strictly anonymous.

USED OIL SURVEY

1. How many cars do you and your family living with you own?_____
2. How often do you change the lubricating oil in your car(s)?
   - ☐ Once every 1-3 months;
   - ☐ Once every 4-7 months;
   - ☐ Once every 8-12 months;
   - ☐ Other (specify) _____
3. Do you usually change the lubricating oil in your car(s) yourself, or do you have the oil changed for you at a service station?
   - ☐ We change it ourselves;
   - ☐ A service station changes the oil.

Please complete the following questions, if you change your oil.

4. Where do you usually purchase the oil? _____
5. What do you do with the used lubricating oil from your car(s)?
   - ☐ We give it to a service station.
   - ☐ We put it in our garbage can.
   - ☐ We pour it out or bury it on our own property (or our neighbor's property).
   - ☐ We pour it on the road.
   - ☐ We pour it down the storm drain or sewer.
   - ☐ We take it to the town dump.
   - ☐ Other (please specify) _____
6. Would you be interested in bringing your used lubricating oil to a recycling barrel if the State of Rhode Island started such a program?
   - ☐ Yes.
   - ☐ Yes, if a recycling barrel were close to our home.
   - ☐ Yes, if a recycling barrel were close to our favorite shopping center.
   - ☐ Yes, if a recycling barrel were located at our town dump.
   - ☐ No, it would not be convenient for us to participate.

Please return the completed questionnaire to us in the envelope provided.

Figure 1

examining the economic feasibility of instituting a waste oil recycling program for the State of Rhode Island and also provided questions asking whether or not they would participate in such a recycling program, and where they thought the recycling centers should be located. Because the covering letter strongly advocated recycling the oil, it is likely that data obtained from this particular survey on the willingness of Providence residents to participate in such a program are apt to be inflated over actual participation unless the program is also strongly advocated to the populace perhaps by a mass media campaign.

individuals (not businesses) were selected from the Providence telephone book using systematic random sampling. Of the 1,000 questionnaires mailed in December 1979, 77 were returned by the post office unopened. On this first mailing 318 usable questionnaires were returned to us. A reminder letter (with a duplicate questionnaire) was mailed a month later to those people not returning the original questionnaire. An additional 174 completed questionnaires were returned to us as a result of this follow-up. There was no significant difference between the disposal methods used by the first responses and those received after the reminder. The only difference observed between these two sets was that after the reminder more people not owning any automobiles returned the questionnaire. Of the 923 questionnaires actually received by residents, 492 usable questionnaires were returned, a rate of 53.3 percent. The standard deviation, σ, expected with this sample population is given in Table 1. These results are representative of the population having listed telephones in Providence.

Results and Discussion

The data obtained in the survey are presented in tabular form. Table 1 contains information on how Providence residents dispose of their waste oil. The percentages are expressed three ways; on the basis of percent-

Table 1. Waste Oil Disposal Practices of Providence Residents Who Change Their Own Oil

Disposal mode	Percentage		
	By respondent $\pm\sigma$	*By vehicle*	*By volume*
Give it to a service station	6.9 ± 2.1	5.6	4.8
Put it in a garbage can	40.7 ± 4.0	46.2	46.7
Pour it or bury it on own property	29.7 ± 3.7	28.6	27.2
Pour it on the road	4.8 ± 1.7	4.3	5.2
Pour it down storm drains or sewers	7.6 ± 2.2	6.8	5.7
Take it to town dump	2.8 ± 1.3	2.1	3.1
Other	7.6 ± 2.2	6.4	6.9
Total number	145	234	522*

*units are vehicle $\times \frac{\text{oil changes}}{\text{yr}}$

age of do-it-yourself respondents using each practice; on the basis of vehicles involved using each practice; and on the basis of volume of oil anticipated. The volume parameter was calculated by multiplying the number of cars/family by the average frequency the respondent reported in oil changes/car/year. (When this value is then multiplied by the average volume of oil used per oil change, i.e. four quarts/oil change, the volume of oil disposed by the survey respondent can be estimated.)

The results indicate that the disposal practices of pouring the oil on the road and dumping it down storm drains or sewers are used by 12.4 percent of the residents. These two practices in Providence directly affect the water quality of Narragansett Bay. Providence's sanitary sewers and stormwater drains are combined throughout 75 percent of the city (Filipone, 1980). Thus most of the waste oil disposed in sewers and on roads ends up in the Providence combined sanitary-storm drain system. Once in this combined system, the wastes flow into the sewage treatment plant which discharges into Narragansett Bay via the Providence River, or when the combined system overflows during heavy rains, the wastes discharge directly into the Providence River.

A comparison of the Providence waste oil disposal practices (Table 1) with those used by Oakland, California, discount store shoppers as reported by Cukor et al. (1973) is given in Table 2. There are several major differences. Because the Oakland survey was conducted among discount store shoppers and this survey was aimed at a wider portion of the populace, it is unwarranted to make in-depth comparisons between

Table 2. Comparison of Waste Oil Disposal Practices of Providence, RI, Residents and Oakland, CA, Residents

Disposal practice	Oakland study*	This work
Put it in garbage can	10%	41%
Pour it out or bury it on own property or neighbors' property	36%	30%
Pour it down storm sewers	11%	8%
Give it to service station	15%	7%
Take it to the town dump	11%	3%
Pour it on the road	—	5%
Other	17%	7%

*from Cukor et al. 1973.

the two surveys. There are obvious regional differences, as mentioned later, but there could be other differences which we cannot assess due to the use of a narrower population segment in the Oakland study. In Providence, the do-it-yourselfers' most popular disposal method was putting the waste oil in their garbage cans (41 percent), whereas, in Oakland, the most popular response was dumping it in their backyard (36 percent). This practice is also somewhat popular in Providence (30 percent) but not to the same extent. The reason for this difference can only be conjectured. Providence is a typical older city in the Northeast where houses are built very close together, close to the street, and with very little land devoted to lawns. It is possible that the practice of dumping the waste oil in the backyard is an inverse relation to the population density. According to the 1970 census, the population density of Oakland was 6,771 persons/square mile while the population density of Providence was 9,901 persons/square mile (U.S. Census Bureau, 1974). Since disposal practices data exist only for these two locations, this conjecture cannot be tested rigorously. The practice of putting oil in the garbage can is apparently the most convenient method of disposing of the oil by Providence residents since the city operates its own garbage collection service. Taking the oil to a public dump in Providence is not as widely practiced as in Oakland because Providence has no active dumpsites in the city (Filipone, 1980). The few Providence residents who said they took their oil to the town dump must be using the town dumps of other surrounding cities or are dumping it surreptitiously at inactive dumps. The practice of giving the waste oil to service stations is also apparently a more popular practice in Oakland (15 percent) than in Providence (7 percent) as well. Until very recently, service stations in Rhode Island were reluctant to accept used oil from do-it-yourselfers. This practice, however, may grow in popularity in Rhode Island due to a recent program started jointly by Ecology Action for Rhode Island and the Ocean State Service Station Owners Association (Montequila, 1979). These owners have agreed to accept waste oil from do-it-yourselfers. However, the program has not been widely publicized and participation, to date, is small.

The fraction who change their own oil versus those who take their cars to a service station is given in Table 3. The data are again expressed in the three ways described previously. The results indicate that 35 percent of the volume of waste automotive lubricating oil is generated by the

Table 3. Lubricating Oil: Do-it-yourselfers in the City of Providence

	% of suvery respondents	*% of vehicles*	*% of oil volume*
Do-it-yourself	33.5	34.3	35.2
Service station users	66.5	65.7	64.8
Number	427*	696	1485

*respondents with cars

do-it-yourself population in Providence. This is somewhat lower than a previous national estimate of 50 percent (Maugh, 1976). We speculate that the do-it-yourselfer population may be smaller in Providence than in more suburban and rural locations because there is, at present, no convenient way to dispose of the waste oil. Several of the respondents expressed interest in changing their own oil if a convenient waste oil disposal method were available.

The apparent willingness to participate in a recycling program in Rhode Island is given in Table 4. The table presents only the responses of the do-it-yourselfers. The survey suggests that a very high degree of cooperation from do-it-yourselfers in a recycling program can be expected. As noted previously, the responses on this portion of the survey could have been biased by the covering letter's strong advocacy of recycling. It is possible, however, for this degree of cooperation in a recycling program to be achieved if the project is well publicized and the program's environmental and economic benefits are explained.

The preferred location for the placement of recycling barrels indicated by the do-it-yourselfers who expressed a preference is given in Table 5. Providence residents overwhelmingly preferred the placement of recycling centers close to their homes. We speculate that convenience

Table 4. Projected Participation of People Who Change Their Own Oil in a Waste Oil Recycling Program

	By respondent	*By vehicle*	*By volume*
Yes, would participate	93.8%	95.3%	93.7%
No, would not participate	4.1%	3.0%	4.6%
No response	2.1%	1.7%	1.7%

Table 5. Location of Recycling Barrels Most Preferred by Do-it-yourself Oil Changers

	By respondent	*By vehicle*	*By volume*
Location close to their home	71.1%	72.0%	69.4%
Location close to shopping centers	24.6%	24.0%	26.4%
Location at town dump	4.3%	4.0%	4.2%

is the most important factor controlling this response. Those initiating recycling programs would be well advised to keep this in mind.

How do the different disposal techniques used in Providence affect the water quality of the Providence River and Narragansett Bay? Two estimates of the amount of lubricating oil sold in R.I. in 1977 are 10,600 metric tons* (3.18 million gallons) according to the U.S. Census (1977), and 12,500 metric tons (3.75 million gallons) according to Federal Highway Administration (1977). It has been estimated that 35 percent of the oil sold in the United States is lost through engine consumption, discarded with the oil filter, or is oil remaining in the crankcase after draining (Fennelly and Spawn, 1978). In Rhode Island this amounts to 4,370 metric tons (1.31 million gallons) annually, leaving the remainder 8,130 metric tons (2.44 million gallons) of used oil to be drained annually. Data from the R.I. Registry of Motor Vehicles indicate that 14 percent of the cars registered in the state are registered in the city of Providence. Using this correction factor, we can estimate that 1,140 metric tons (342,000 gallons) of waste lubricating oil are generated by Providence residents annually. Although previous estimates have indicated that 50 percent of the oil is changed by do-it-yourselfers on a national basis (Maugh, 1976), our survey of Providence residents indicates that only about 35 percent of them change their own oil (Table 3). Do-it-yourselfers in Providence therefore generate approximately 400 metric tons (120,000 gallons) of waste lubricating oil annually. On a volume basis, the survey indicates that 10.9 percent of the waste oil generated by do-it-yourselfers is dumped in sewers (5.7 percent) or poured on the roads (5.2 percent) (Table 1). This would

*Original data were in gallons; assuming a specific gravity of 0.9, one metric ton is approximately 300 gallons.

indicate that 44 metric tons (13,100 gallons) of petroleum hydrocarbons are discharged annually into Narragansett Bay via the Providence River from this sewage treatment facility and combined sewage overflow outfalls from this one disposal practice. Based on a 1974–75 study, 226 metric tons of petroleum hydrocarbons per year are discharged into the Providence River via the Providence sewage treatment plant (Van Vleet and Quinn, 1977). Thus the practice of disposing of waste oil in the sewers may account for approximately 19 percent of the petroleum hydrocarbons discharged by this sewage treatment facility assuming that all of this oil goes through the plant. This rate if projected to the discharge of lubricating oil from all treatment facilities and combined sewer overflows in Rhode Island, most of which discharge into Narragansett Bay or its tributaries, could amount to 310 metric tons/year. It should be noted that in 1976 direct oil spills in Narragansett Bay amounted to approximately 55 metric tons/year (U.S. Coast Guard data for 1976) (Morgan, 1978).

Our data can be applied to all U.S. coastal communities if the following assumptions are made: 8×10^6 metric tons (2.4×10^9 gallons) of lubricating oil were sold in the U.S. in 1975 (Maugh, 1976); 4×10^6 metric tons (1.2×10^9 gallons) were consumed in use; approximately 2.87×10^6 metric tons (860×10^6 gallons) were reclaimed leaving 1.13×10^6 metric tons (340×10^6 gallons) unaccounted for (American Petroleum Institute, 1974); 60 percent of the oil is from automobiles (ibid.); assume a do-it-yourselfer population of 35 percent; 34 percent of the U.S. population live in coastal communities (National Academy of Sciences, 1975), 10.9 percent of the do-it-yourselfers dump their oil on the roads or down sewers (this work, Cukor et al., 1973). The calculations suggest that approximately 8,800 metric tons of oil goes into coastal waters solely from the practice of people dumping their waste oil down sewers or on roads. Since it has been estimated that coastal communities via their sewage treatment facilities release about 51,000 metric tons of petroleum hydrocarbons per year to coastal waters (Van Vleet and Quinn, 1978), on a nationwide basis, approximately 17 percent of this value can be explained by the practice of do-it-yourselfers dumping their waste lubricating oil down sewers or on roads.

It should also be pointed out that the practices of disposing of the waste oil on land via taking it to dumps directly or via putting it in garbage cans or pouring it out in the backyard can also affect water

quality by contaminating land runoff, urban runoff, and groundwaters with petroleum hydrocarbons; but the impact of these practices on Narragansett Bay is more difficult to assess.

Recently the R.I. Legislative Commission on Used Oil estimated that between 0.57 and 1.64 million gallons of potentially recyclable used oil are being discarded annually in the state. The estimated value, based on a rate of $0.10 per gallon is $60,000–$160,000. The potential value of this oil after treatment is worth at least $180,000–$480,000 based on a cost of $0.30 per gallon. Based on these economic considerations and environmental concerns, the State of Rhode Island passed waste oil recycling legislation, in April 1980, authorizing the R.I. Department of Environmental Management (DEM) to organize a voluntary program. As of July 1980, the DEM had already recruited 73 service stations to serve as collection centers. Posters for these service stations, and posters with lists of stations participating in the program for display at large-volume lubricating oil outlets will be available in October 1980. The estimated cost to the state to set up this program is $6,000 (Keegan, 1980).

Summary and Conclusions

It was estimated on the basis of a 1979–80 survey of Providence residents that 10.9 percent (or about 44 metric tons per year) of the waste lubricating oil generated by those of this city's residents who change their own oil is dumped onto roads or into storm sewers. A previous study reported that about 226 metric tons of petroleum hydrocarbons were discharged from the Fields Point Sewage Treatment Plant during a one-year period from 1974 to 1975. During 1976, 55 metric tons of oil were directly spilled in the bay from all sources other than sewage effluents. Thus, if all of the waste lubricating oil enters the Fields Point facility, it could account for approximately 19 percent of this plant's annual discharge of petroleum hydrocarbons into the Providence River and is about equivalent to the amount spilled directly into Narragansett Bay. Providence residents indicated a high degree of willingness to participate in a recycling program recently passed by the State Legislature of Rhode Island. Such a program could have only a beneficial effect on the water quality of Narragansett Bay, long recognized as Rhode Island's most valuable natural resource.

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References

American Petroleum Institute Committee on Disposal of Waste Products, 1974. "Waste Oil Roundup, No. 3." American Petroleum Institute No. 1587, Washington, DC. 33 pp.

Boehm, P. D., and J. G. Quinn, 1977. "The persistence of chronically accumulated hydrocarbons in the hard shell clam *Mercenaria mercenaria*." *Marine Biol.* 44:227–233.

Cukor, P. M., M. J. Keaton, and G. Wilcox, 1973. A technical and economic study of waste oil recovery, Part II: an investigation of dispersed sources of used crankcase oils. EPA/530/SW-90C.2. 67 pp.

Farrington, J. W., and J. G. Quinn, 1973. "Petroleum hydrocarbons in Narragansett Bay: Survey of hydrocarbons in sediments and clams." *Est. Coast. Mar. Sci.* 1:71–79.

Federal Highway Administration, "Excise Tax Data," Washington, DC, 1977.

Fennelly, P., and P. D. Spawn, 1978. Waste oil recovery and reuse in Massachusetts—an updated evaluation, Technical Report, GCA Corp.

Filipone, J., 1980. (City Engineer), Providence, R.I., personal communication.

Keegan, S. M., 1980. (Public Participation Coordinator, R.I. Department of Environmental Management) personal communication.

Maugh, T. H., II, 1976. "Rerefined oil: an option that saves oil, minimizes pollution." *Science* 193:1108–1110.

Montequila, P., President, Ocean State Service Station Operators Assoc., testimony before the R.I. Special Legislative Commission on waste oil recycling, Nov. 8, 1979.

Morgan, T. J., 1978. "142 oilspills pollute the bay during the first half of last year." *Providence Sunday Journal*, Feb. 5, 1978.

National Academy of Sciences, 1975. Petroleum in the marine environment. Workshop on inputs, fates and effects of petroleum in the marine environment. Washington, DC, 107 pp.

R.I. General Assembly, 1980. Report of the Legislative Commission on Used Oil, 28 pp., February, 1980.

Tanacredi, J. T., 1977. "Petroleum hydrocarbons from effluents: detection in the marine environment." *J. Wat. Poll. Cont. Fed.*, 49:216-226.

U.S. Bureau of the Census, 1974. Statistical abstract of the United States 1974, U.S. Dept. of Commerce, 95th edition.

U.S. Bureau of the Census, 1977. Biannual survey of lubricating oil sales. U.S. Dept. of Commerce, Washington, DC.

U.S. Coast Guard, 1976. Polluting incidents in and around U.S. waters, 1975. USCG (CG-487), Washington, DC.

Van Vleet, E. S., and J. G. Quinn, 1977. "Input and fates of petroleum hydrocarbons entering the Providence River and upper Narragansett Bay from waterwaste effluents." *Environ. Sci. Technol.* 11:1086–1091.

Van Vleet, E. S., and J. G. Quinn, 1978. "Contribution of chronic petroleum inputs to Narragansett Bay and Rhode Island Sound sediments." *J. Fish. Res. Board Can.* 35:536–543.